Carbon Cycling in the Southern Great Plains: The ARM/LBNL Carbon Project

Margaret S. Torn, Marc L. Fischer, William J. Riley, Sébastien C. Biraud, and Joe A. Berry
Contact: Margaret S. Torn, 510/495-2223, MSTorn@lbl.gov

RESEARCH OBJECTIVES

The DOE Atmospheric and Radiation Measurement (ARM)/Berkeley Lab Carbon Project is making a coordinated suite of carbon concentration, isotope, and flux measurements to support a range of scaling and integration exercises, including those proposed for the North American Carbon Program:

- Quantifying regional atmospheric CO_2 sources and sinks
- Developing land-surface models and testing carbon exchange parameters
- Predicting the effect of land use and climate on carbon and energy fluxes
- Testing innovative methods for inferring carbon fluxes

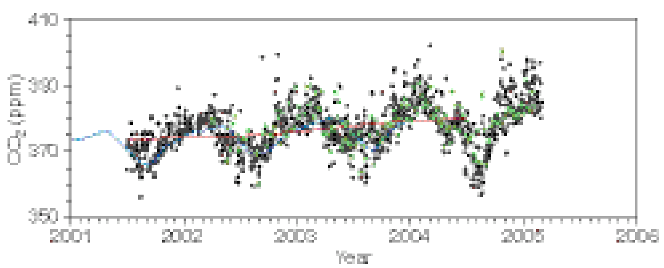

Figure 1. Precise atmospheric CO_2 concentrations (black circles) measured at 60 m, during well-mixed, afternoon conditions (14:00–17:00 CST daily). The running average (black line) shows the seasonal cycle amplitude at ~15 ppm, with a minimum at the peak N Hemisphere growing season, rather than peak local growing season in late spring. The average annual trend in ARM data (red line) matches the NOAA network trend for the SGP latitude band (dashed line). The NOAA flasks were collected ~14:30 CST weekly.

APPROACH

We are working in the ARM Southern Great Plains test bed, a 300 × 300 km area of Oklahoma and Kansas. Most of our carbon measurements are collected at the 60 m tower of the ARM Central Facility, including precise CO_2 concentration profiles, carbon eddy covariance fluxes, National Oceanic and Atmospheric Administration (NOAA) flasks in the mixed layer and free troposphere (by aircraft), and diurnal profiles of ^{13}C and ^{18}O in CO_2. The precise CO_2 measurements and NOAA flasks tie the ARM site to the global atmospheric network. This year, we have added continuous CO measurements and are in the process of adding continuous airborne CO_2 and $^{14}CO_2$ flask sampling to assist with source attribution.

ACCOMPLISHMENTS

By comparing airborne and tower data, we have found that the 60 m tower is tall enough to sample well-mixed boundary-layer air during the afternoon, when convective mixing is active. As a result, our data can be used to estimate regional CO_2 levels. Figure 1 shows daily CO_2 concentrations measured in the afternoon during well-mixed conditions. The annual increase over three years was more than 2 ppm y^{-1}. This trend nearly matches the global background trend (2.3 ppm y^{-1}) reported by NOAA at Mauna Loa.

Using multiple eddy flux towers, we find large heterogeneity in surface fluxes among replicate wheat fields and even larger variability between different cover types. These findings reinforce the need for model parameters that accurately represent heterogeneity in land use, to replace the typical application of a single parameter set for all crop types. We have begun testing distributed ecosystem model predictions against the eddy flux measurements, and plan to compare the distributed model results with atmospheric inversion results for estimating mesoscale carbon fluxes.

SIGNIFICANCE OF FINDINGS

As shown in Figure 1, global atmospheric CO_2 concentrations are rising rapidly. The rate of increase is the difference between anthropogenic emissions and uptake by land and oceans. The ability to predict or manage future CO_2 concentrations, and thus climate itself, depends on our ability to understand and predict terrestrial carbon exchanges. Our research at ARM addresses this need by quantifying subcontinental-scale ecosystem-atmosphere fluxes, and predicting the effects of land use and climate on atmospheric CO_2 concentrations.

RELATED PUBLICATIONS

Billesbach, D.P., M.L. Fischer, M.S. Torn, and J.A. Berry, A portable eddy covariance system for the measurement of ecosystem-atmosphere exchange of CO_2, water vapor, and energy. The Journal of Atmospheric and Oceanic Technology, 21: 684–695, 2004. Berkeley Lab Report LBNL-55170.

Cooley, H.S., W.J. Riley, M.S. Torn, and Y. He, Impact of agricultural practice on regional climate in a coupled land surface mesoscale model. JGR-Atmospheres, 110, D03113, 2005. Berkeley Lab Report LBNL-56063.

RELATED WEB SITE

ARM Carbon Web Site: http://esd.lbl.gov/ARMCarbon/

ACKNOWLEDGMENTS

This work was supported by the Director, Office of Science, Office of Biological and Environmental Research, Climate Change Research Division, Atmospheric and Radiation Measurements Program, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.